Committee on Resources,

Subcommittee on Fisheries Conservation, Wildlife & Oceans

fisheries - - Rep. Wayne Gilchrest, Chairman
U.S. House of Representatives, Washington, D.C. 20515-6232 - - (202) 226-0200

Witness Statement

Statement of Steven A. Murawski, Ph.D., Chief Stock Assessment Scientist, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts

Thank you, Mr. Chairman, for your kind invitation to provide testimony regarding ecosystem-based management and specifically aspects related to the Northeast United States continental shelf. My name is Steven Murawski, and I am the Chief Stock Assessment Scientist for the Northeast Fisheries Science Center, in Woods Hole, Massachusetts. In my oral and written testimony I will detail a case history of overfishing on an ecosystem-wide basis. The Northeast shelf ecosystem is one of the best-studied areas of the world's oceans. Fishery-independent monitoring programs have been in place for nearly four decades, and the predator-prey interrelationships and effects of variation in the marine environment on species of the Northeast have been extensively studied. Had prescriptive scientific advice, based on traditional models and data, been followed, many of the difficulties we now face in stock rebuilding could have been avoided. Nevertheless, there is a critical need for the inclusion of ecosystem considerations in the management of this system, and ecosystem issues will have an increasingly important and central role in setting biomass rebuilding targets, optimizing yields from interrelated species and fisheries, minimizing habitat damage caused by gear, and in dealing with overcapacity of a mobile, efficient, and adaptable fishing fleet.

The Northeast USA: A Case History of Ecosystem Overfishing

Off the Northeast USA (Cape Hatteras to the Canadian Maritimes) there are about four dozen important finfish and shellfish stocks that require intensive monitoring and scientific advice to support fishery management plans. These stocks include New England groundfish (a complex of about 15 species and 25 managed stocks), summer flounder, sea scallop, Atlantic herring and mackerel, striped bass, surfclam and monkfish, to name a few. Virtually all of these important stocks have undergone dramatic population declines during the past two or three decades, necessitating the development of restrictive management measures to address overfishing (Exhibit 1). In a number of important cases these plans, which have usually been developed for individual species or sets of species caught together when fishing, have resulted in some level of stock rebuilding. Thus, for example, we have seen increases in the stock sizes and landings of striped bass, summer flounder, sea scallop, and some stocks in the groundfish complex. Rebuilding of these stocks has required substantial cuts in fishing mortality through the imposition of strategies to reduce fishing pressure (effort), the closure of large areas of productive ocean waters to fishing, in some cases the adoption of low annual landings quotas, and other measures.

It is often suggested that the depletion of these Northeast fishery resources (and more generally those throughout the nation and the world) stems in part from our failure to adopt an holistic "ecosystems approach" - fisheries management and resource conservation being too focused on single-species stock status and control strategies (Murawski 2000). The primary cause of the collapse of many Northeast stocks clearly was excessive fishing - scientific advice from single-species stock assessments predicted as much. Nevertheless, it is appropriate to consider how systems might be assessed and managed, and what additional benefits could be expected from an explicit ecosystem orientation. The important questions in this regard are, then:

- •What might be accomplished by developing criteria for defining ecosystem-level overfishing and management measures that could not be accomplished under effective single- or multiple species fishery management plans?

- •Are single-species recovery strategies possible or desirable for complex marine ecosystems, and if so, what characteristics of ecosystems should be considered when developing stock rebuilding targets and thresholds?
- •Can fisheries research provide a quantifiable basis for defining ecosystem overfishing and acceptable standards to measure progress against those definitions?
- •What additional monitoring and research would be necessary (over and above that necessary to support species management) to support ecosystem-based fishery management?

The situation off the Northeast USA provides some useful insights into these questions; as a case history, these fisheries are often regarded as a prime example of ecosystem-level overfishing (Hall 1999; Fogarty and Murawski 1998).

While overfishing of some species was evident as early as the late 1920s (i.e., Georges Bank haddock and Atlantic halibut), overfishing on an ecosystem scale did not occur in the Northwest Atlantic until the early 1960s, with the massive influx of effort from European and later Asian distant-water fleets. The scale of the effort increases in the 1960s and early 1970s was so massive that the system showed rapid and broad-scale declines in the fish populations off the coast (Exhibit 1). These fleets of large vessels could not survive on low catch rates and thus the distant-water fleets engaged in a strategy of switching from one abundant target species to another in a now classic pattern termed "sequential depletion" (Orensanz et al. 1998). In this fishing pattern, multispecies catch rates are maintained, for a while, by re-targeting fisheries to abundant or valuable resources, with fishery management structures unable to anticipate or keep up with the changes in fishing patterns. The severe depletion of traditional USA groundfish species such as haddock, whiting (silver hake), red hake, and yellowtail flounder was followed by shifts and collapses in herring, mackerel, and other species important to the functioning of the fish component of the ecosystem (Exhibit 1; Fogarty and Murawski 1998). The fishery initially focused on predators and other high level consumers, and later on fish species of lower position in the food web (Sissenwine et al. 1984), consistent with a strategy of "fishing down the food web" (Pauly et al. 1998). The collapse of herring and mackerel stocks - primary prey for a number of predators such as cod, whiting, dogfish, and pollock, resulted in substantial shifts in diet composition and consumption rates by these predators (Overholtz et al. 2000), and resulted in substantial increases in other species including sand eels (Fogarty et al. 1991).

A comprehensive fishery research strategy to index all the marine fish components of the Northeast ecosystem was introduced in the early 1960s, coincident with the influx of distant-water fleet effort. The delivery of the R/V *Albatross IV* in 1962 provided for the first time an adequate platform from which to mount system-wide bottom trawl surveys in the nearly 250,000 km^2 Northeast continental shelf ecosystem. These surveys, undertaken in a statistically rigorous manner for nearly 40 years, provide the basis for single-species stock assessments and other data about the ecosystem. It is these data (Exhibit 1) that documented clearly the impacts of fishing on individual stocks and species groups. In addition to abundance and biological measurements of individual stocks, stomach sampling information obtained from the surveys has allowed for modeling of the impacts of predator-prey interactions (Overholtz et al. 2000).

Fishery management in the 1970s was primarily undertaken through the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Eventually ICNAF adopted comprehensive quota management systems for primary target species, and an overall cap on fisheries removals (similar to that now in effect in the Bering Sea) to address predator-prey and bycatch problems. This regime ended in 1976 with the adoption of the Magnuson Act.

With the adoption of domestic management programs, most quota-based management of finfish resources was phased-out in the early 1980s in favor of "indirect" controls on fishing such as minimum fish and mesh sizes. Although stock assessments showed increased fishing mortality rates and declining biomasses of the valuable stocks, fishery management responses were too slow to respond and generally inadequate. Landings of groundfish stocks increased in the early 1980s due to good recruitment from the mid 1970s, but later declined severely due to high harvest rates and recruitment failure (Exhibit 2). Beginning in the early 1990s, fisheries management again instituted systems of direct controls including "hard" quotas for a number of Mid-Atlantic species (summer flounder, surfclam, ocean quahog, mackerel, scup, squids), and effort control for New England groundfish, sea scallop, and monkfish. Combined with the large scale closure of productive fishing grounds in New England (Exhibit 3), management has achieved lower mortality rates for most valuable stocks and abundance has improved.

For some stocks such as herring and mackerel, domestic fisheries have never generated fishing mortality rates as high as those achieved under the foreign fishing regime, and these stocks increased rapidly to very high levels after 1976 (Exhibit 1). Currently, herring and mackerel are abundant and relatively productive, and are consumed by a wide variety of fish, seabirds, and marine mammals. The recovery of these species was an early indication that the effects of ecosystem-level overfishing were not necessarily irreversible - that important components of the ecosystem could be recovered despite the complexity of species interactions and fisheries.

Studies of the food web supporting the shelf fisheries have demonstrated just how complex the system is (Link 1999). However, despite this complexity, research has demonstrated that the system is not so tightly bound that recovery potential is severely limited by dominant predator-prey relationships. One of the most important observations of the Georges Bank GLOBEC research program is that environmental variability has a significant influence of the survival of young fish (Fogarty and Murawski 1998). Other recent studies have also shown that there are substantially greater odds of getting strong replenishment of groundfish occurring when spawning biomasses are high (Brodziak et al. 2001). The empirical observations of the recovery of prey species like herring and mackerel, combined with information demonstrating the importance of adequate spawning biomass, and the roles of oceanographic variability, have all strengthened the case for aggressive management for stock recovery and eventual fisheries sustainability at levels approaching MSY.

The Role of Ecosystem Considerations

All of the stocks regulated under Federal FMPs have, as their fundamental basis, the definitions of overfishing and attendant control rules set so that fishing mortality rates do not exceed the level that is necessary to achieve maximum sustainable yield (MSY). Further, biomass targets are established for each of the major stocks, based on the likely recovery potential by using analyses of historical fisheries and research data. It is clear that the establishment of target biomasses under the single species approach leaves many unanswered questions. A primary question of great current importance is: what is the biomass and yield potential for stocks that have been chronically overfished throughout the period for which there are landings and population data? It is possible that the yield potentials of some stocks, like Georges Bank haddock and yellowtail flounder, sea scallop, and summer flounder are different than those indicated by single-species models of stock recovery and yield. In these cases we simply may not be able to ascertain these quantities *de novo* from the historical data - an adaptive, cautious management approach to exploring the yield and biomass potentials of stocks may be required. By the same token, a comprehensive approach to defining biomass necessary for MSY for each stock individually may not be feasible given the limits on fish biomass and yield imposed by primary production (photosynthesis) and zooplankton production. Simply stated, the whole may be less than the sum of the parts. It is clear that the current approach, as implemented in Northeast FMPs for individual species and species assemblages, has no mechanism to incorporate ideas regarding predator-prey relationships and the feasibility of biomass goals and possible trade offs. Likewise, bycatch interactions, wherein the target fisheries regulated in one FMP generate bycatches of species controlled by another, are also not now addressed in a systematic manner. An umbrella fisheries ecosystem plan would be a valuable addition to address these concerns.

Another issue that could be better addressed with an ecosystem focus to FMP development is the effect of effort control programs on non-target species. The depletion of groundfish and other high values species was followed by a more recent round of shifting fisheries to alternative target species (Exhibit 4). In this scenario, effort from the traditional groundfish and scallop fisheries was diverted to non-traditional stocks including monkfish, spiny dogfish and squids. In the case of groundfish, effort was halved in the mid-1990s, with some of the remaining effort flowing to these alternative targets. Managers have had to play catch up to address overfishing concerns of these secondary target species. This scenario could have been addressed through a comprehensive approach to fishing effort and capacity management - the current system recognized the potential of effort movement between fisheries but has not managed capacity in a comprehensive manner. Clearly, recognizing that fishing effort can be deployed in flexible and efficient ways should be an important consideration in managing fishery ecosystems.

Fishery managers in New England and the Mid-Atlantic have been among the first to adopt the use of large-scale year round fishery closures in order to achieve management goals for target species (Exhibit 3; Murawski et al. 2000). Large areas (over 20,000 km^2 in the case of groundfish closures) of productive fishing grounds were closed beginning in 1994. These areas have proved to be a significant element in the plan to increase groundfish abundance. At the same time, the enactment of these areas have had serendipitous effects demonstrating the value of closed areas as a strategy for increasing the abundance of sea scallop and other species (Murawski et al. 2000). These closures, although enacted for very specific and limited fishery management goals, have coincided with a heightened interest world-wide in the use of marine protected areas (MPAs). Although most monitoring studies have focused on the overall status of regulated stocks, some limited field study conducted by the NEFSC and academic partners have revealed changes in the benthic community structure and habitat associated with the closures (Collie et al. 1997). Prior to the limited resumption of scallop dredging in portions of the groundfish closure areas, comparative habitat studies were initiated - the results of which are only now being interpreted. Based on preliminary analyses, it is clear that the cessation of fishing in these habitats has had measurable effects on the biota in the closed areas. We do not yet know the significance of these changes to either the target species (improved juvenile survival?) or on other non-resource species. There is an indication of increased biodiversity of the fish component of the resource since the adoption of these closures, and there are some similar effects outside the closures (Exhibit 5; Brodziak and Link 2001). However, intensive studies of the effects of these closures and their roles within the broader ecosystem have not been initiated. Closed areas (rotational, seasonal, year-round, and marine reserves wherein no fishing activity at all is allowed) will be a significant component of fishery and ecosystem management in the years to come, and programs to evaluate the potential costs (through lost fishing opportunities) and benefits of such closed areas are a priority. Fishery closures in New England have resulted in trawl fishing effort moving into habitats that heretofore were not as heavily utilized (Exhibit 6). These effects need to be better understood as MPAs become more widely established as fishery and ecosystem management tools.

Summary

Overfishing of Northeast fishery resources occurred primarily as a result of the lack of direct controls on fishing mortality. As a wider array of species comes under intensive management, and stocks begin to recover, there is an even greater need to address ecosystem considerations. It is not clear that we can achieve biomass targets determined based on single-species models and data for all managed stocks simultaneously, and it is likely that species interactions will increasingly modify the rates of recovery of stocks. Fishery management plans for individual species and species groups do not allow a convenient forum in which to assess inherent tradeoffs due to predator-prey or bycatch interactions. Furthermore, the current structure does not allow a comprehensive effort control and management system. Comprehensive effort management has been identified as an essential component of ecosystem-based fishery programs. The effects of mobile fishing gears on the characteristics and productivity of benthic habitats has also been identified as a priority, but studies of these phenomena and their importance in managing exploited ecosystems has not been adequately assessed anywhere in the world. The Northeast USA shelf ecosystem has been intensively trawled and dredged for 100 years, and changes in these habitats have no doubt occurred. Marine protected areas have the potential to mitigate some of these effects, but the extent and direction of habitat changes with the cessation of trawling and dredging is only now beginning to be appreciated, especially in New England. This issue will take on a central role in fisheries management and research in the years to come.

In the absence of a quantitative understanding of species interactions and impacts of habitat alterations, there is a growing consensus of scientific opinion that prescriptive management provided by conservative single-species approaches will provide the balance among ecosystem components and high and relatively sustainable fishery yields. A better understanding of these issues will allow managers to assess the potentials and tradeoffs that will result from more active management of the various components of the ecosystem.

Research Needs to Support Ecosystem Considerations:

Ecosystem approaches, whether implemented as perspectives on traditional overfishing approaches, or through explicit ecosystem-based definitions, require research and advisory services not typically provided by fish stock assessment science. Regardless of the approach, additional ecosystem monitoring and research is necessary with increased emphasis on species interactions, diversity (at all levels of organization) and variability (at various temporal and spatial scales). However, this does not necessarily imply that traditional programs collecting fishery-dependent and fishery-independent information should be abandoned. On the contrary, existing programs will need to be expanded to allow monitoring of catches and abundances of a wider array of species, to complement research and modeling on trophic interactions and other processes. Such research is necessary if ecosystem considerations are to assume a greater role in resource management, particularly as habitat protection becomes a priority, and measures such as marine protected areas are used more widely to enhance resource and non-resource species protection. Specifically, I foresee added research emphasis in these areas:

- •predation studies
- •measures of species diversity and their relation to harvesting
- •field studies of closed areas (emphasizing their role as essential fish habitat)
- •models of species and habitat interaction (spatially explicit)
- •enhanced capabilities to comprehensively monitor components of the ecosystem through fishery independent surveys

---

References

Brodziak, J.T.K. and J.S. Link 2001. Ecosystem-based fisheries management: What is it and how can we do it? Bulletin of Marine Science (in press).

Brodziak, J.K.T., W.J. Overholtz and P.J. Rago. 2001. Does spawning stock affect recruitment of New England groundfish? Canadian Journal of Fisheries and Aquatic Sciences 58(2): 306-318.

Collie, J.S., G.A. Escanero, and P.C. Valentine. 1997. Effects of bottom fishing on benthic megafauna of Georges Bank. Marine Ecology Progress Series 155: 159-172.

Fogarty, M.P., E.B. Cohen, W.L. Michaels, and W.W. Morse. 1991. Predation and the regulation of sand lance populations: an exploratory analysis. ICES Symposium of Marine Science 193: 120-124.

Fogarty, M.P. and S.A. Murawski. 1998. Large-scale disturbance and the structure of marine systems: fishery impacts on Georges Bank. Ecological Applications 8(1, Supplement): S6-S22.

Hall, S. 1999. The effects of fishing on marine ecosystems and communities. Blackwell Science, London.

274 pp.

Link, J. 1999, (Re)Constructing food webs and managing fisheries. Ecosystem Approaches for Fisheries Management. Alaska Sea Grant College Program. AK-SG-99-01. 571-588.

Murawski, S.A. 2000. Definitions of overfishing from an ecosystem perspective. ICES Journal of Marine Science 57: 649-658

Murawski, S.A., R. Brown, H.-L. Lai, P.J. Rago and L. Hendrickson. 2000. Large-scale closed areas as a fishery-management tool in temperate marine systems: the Georges Bank experience. Bulletin of Marine Science 66(3): 775-798.

Orensanz, J.M., J,. Armstrong, D. Armstrong, and R. Hilborn. 1998. Crustacean resources are vulnerable to serial depletion - the multifaceted decline of crab and shrimp fisheries in the Greater Gulf of Alaska. Reviews in Fish Biology and Fisheries 8:117-176.

Overholtz, W.J., J.S. Link and L.E. Suslowicz. 2000. Consumption of important pelagic fish and squid by predatory fish in the northeastern USA shelf ecosystem with some fishery comparisons. ICES Journal of Marine Science 57: 1147-1159.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. Torres, jr. 1998. Fishing down marine food webs. Science 279:860-863.

Sissenwine, M.P., E.B. Cohen and M.D. Grosslein. 1984. Structure of the Georges Bank ecosystem. Rapports et Process verbaux des Reunion International de Conseil de Exploration de la Mer 183: 243-254.

# # #